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Negative emotional stimulation decreases respiratory sensory gating in healthy humans☆

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ABSTRACT

We tested the hypothesis that negative emotions decrease the respiratory-related evoked potentials (RREP) sensory gating (RSG). RREP were elicited by paired inspiratory occlusions. RSG was calculated as the difference in the averaged RREP peak N1 amplitude between the second (S2) and the first occlusion (S1). RSG was compared between unpleasant and neutral emotional conditions elicited by viewing affective pictures from the IAPS system in thirteen healthy adults. Results are expressed as median [min; max]. Compared to neutral pictures, viewing unpleasant pictures decreased the RREP N1(S1) amplitude (−3.37 μV [−4.62; −1.37] versus −4.59 μV [−6.08; −1.36]; $p = 0.017$) but not the RREP N1(S2) amplitude (−0.26 [−3.24; 2.36] versus −0.7 [−1.54; 3.6]; $p = 0.68$), and reduced the difference score S2–S1 (3.73 μV [0; 5.82] versus 4.79 μV [3; 6.2]; $p = 0.038$). We concluded that a negative emotional stimulation could attract subject's attention to the detriment of the respiratory sensory inputs and produced an overall decrease in the RSG. This latter finding might participate in an over-perception of repeatedly presented respiratory stimuli.

1. Introduction

Sensory perception is the act of interpreting and organizing sensory information, or sensation, to produce a meaningful experience of the world and of oneself (De Ridder et al., 2011). The perception of respiratory sensations in particular functions to warn the organism that an unusual respiratory event has occurred. Thus, dyspnea, or unpleasant respiratory sensation (Parshall et al., 2012), should induce a strong alarm of respiratory difficulty resulting in breathing pattern changes and specific actions (von Euler, 1981). In asthma, for example, the perception of bronchoconstriction induces dyspnea, increases the respiratory rate (Tanaka et al., 1990) and leads patients to take rescue medication. However, the perceived respiratory sensation does not strictly correlate with the magnitude of the corresponding stimulus. This has been largely investigated in asymptomatic bronchial hyperresponsiveness (Brand et al., 1992) and asthma (Bijl-Hofland et al., 1999; Burdon et al., 1982; Dahme et al., 1996; Grazzini et al., 2002; Kendrick et al., 1993; Rubinfeld and Pain, 1976; Wamboldt et al., 2000), where a similar fall in the forced exhaled volume in 1 s (FEV1) provoked respiratory sensations of variable intensity. As no pulmonary physiological deficit could explain this variability (Boulet and Turcotte, 2007), subjects were categorized in over-, normo- and poor-perceivers (Boulet et al., 1994). Based on clinical and experimental observations (De Peuter et al., 2008; Giardino et al., 2010; Li and Puntillo, 2006;

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Livermore et al., 2008; Nardi et al., 2009; Spinhoven et al., 1997; von Leupoldt et al., 2006), the idea emerged that psychological factors could modify respiratory sensory perception (Boulet et al., 1991; Gibson, 1995). However, objective modulation of respiratory sensory processing by emotion has not been studied extensively. In the present study, we investigated the impact of experimentally elicited unpleasant and neutral emotions on the cortical neural processing of respiratory sensations.

The respiratory related evoked potential (RREP) is one of the neural correlates of respiratory sensory perception (Davenport and Vovk, 2009). The RREP is produced by a mechanical stimulus, such as an inspiratory load or an inspiratory occlusion (Chan and Davenport, 2010a). Activation of intercostal, diaphragmatic and upper airway mechanoreceptors produces an afferent neural signal that projects into the brain and is processed by subcortical and cortical structures (Chan and Davenport, 2010a; Davenport and Vovk, 2009; Donzel-Raynaud et al., 2004). The neural dipole potential derived from the summed cortical activity, or RREP, displays three early peaks (Nf, P1 and N1) (Davenport et al., 1986) and two late peaks (P2 and P3) (Webster and Colrain, 2000b). The RREP is directly related to respiratory sensory perception in healthy subjects and in life-threatening asthma patients (Davenport et al., 2012, 2000; Knafelc and Davenport, 1999). Emotion does not modify the amplitudes of the RREP early peaks (von Leupoldt et al., 2010b) suggesting that affect does not act on respiratory perception by increasing the respiratory sensory-related discriminative cortical activity.

Neural gating is the brain mechanism to filter continuous sensory inputs before they reach high level cortical processes in order to suppress redundant or insignificant stimuli (Cromwell et al., 2008). This central neural process is present for most somatosensory modalities including respiratory sensations. Studying the respiratory sensory cortical gating requires the production of two successive and similar inspiratory occlusions within a single inspiration. The first inspiratory occlusion is thought to generate a memory trace to which the second is compared upon arrival. Processing of the second occlusion is then actively inhibited within a specific period (usually less than 1 second) as this repetition contains no new information. For gating of the RREP, the amplitude of the second stimulus-elicited N1 peak is lower than the amplitude of the first stimulus-elicited N1 peak (Chan and Davenport, 2008). We hypothesize in the present study that negative emotion can decrease the respiratory sensory gating. The effect of unpleasant emotion induced by affective pictures on the respiratory sensory gating was assessed using the RREP measure in healthy subjects.

2. Methods

2.1. Ethics

The study was approved by the Institutional Review Board at the University of Florida (IRB201300648). All participants received oral and written information and provided written informed consent to participate in the study.

2.2. Subjects

Spirometry was performed to exclude airway obstruction defined as a ratio FEV1/FVC less than 0.7. Anxiety state was assessed before the onset of the experiment by the State-Trait Anxiety Inventory questionnaire (Spielberger et al., 1970). State anxiety (anxiety just before the experiment) and Trait anxiety (general anxiety) were scored from 20 (no symptoms) to 80 (maximum symptoms). Sixteen healthy adults (8 males and 8 females) participated in the study. Three of them were excluded because of airway obstruction in one case, failure to complete the experiment in one case and inappropriate emotional response to IAPS pictures in one case.

2.3. Procedure

Participants sat comfortably in a recliner located in a sound and light-attenuated room separated from the researcher. During the experiment, the researcher monitored the subject's behavior with a camera but no images were recorded. Participants breathed through a breathing circuit consisting of a mouthpiece, a pneumotachograph and a non-rebreathing valve. The inspiratory port was connected to an occlusion valve with reinforced tubing. A noseclip prevented nasal airflow. This breathing circuit allowed the application of inspiratory occlusions and the monitoring of respiratory pattern. The experiment included two emotional conditions, unpleasant and neutral, provoked by watching affective pictures from the International affective picture system (IAPS) (Lang et al., 2008). A 5-min break separated the two experimental conditions. The condition order was randomized. Paired inspiratory occlusions were applied to the subject while respiratory and electroencephalographic (EEG) data were recorded (Chan and Davenport, 2008). After each condition, participants rated the emotional and respiratory feelings experienced on the Self-Assessment Manikin (SAM) and the modified Borg scale, respectively.

2.4. Experimental emotion induction (affective picture series)

Emotional states were evoked by watching unpleasant and neutral pictures from the IAPS (Lang et al., 2008), a commonly used and standardized method for experimental emotion induction. The experienced emotional states during picture viewing are usually rated according to their hedonic valence and arousal. Thirty unpleasant pictures (high arousal and low valence) and thirty neutral pictures (low arousal and medium valence) were selected from the IAPS system. Pictures were displayed on a 71 × 40 cm monitor placed 2 meters in front of the participants. After the projection of a black screen for 1 min, pictures from one set (unpleasant or neutral) were randomly presented for 10 s each, using experimental stimulus software (Presentation, Neurobehavioral Systems Inc.). The picture set was repeated four times resulting in a 20-min sessions for each condition. Picture hedonic valence and arousal were rated using a paper and pencil version of the SAM (Bradley and Lang, 1994) based on a 1 to 9 illustrated scale.

2.5. Inspiratory occlusions

Subjects were informed that respiration would be occasionally obstructed for a very short time and they were trained to breathe through the breathing circuit with and without inspiratory occlusions. Paired occlusions were applied every one to four inspirations according to a random algorithm. Occlusions were initiated manually by the researcher immediately after the onset of inspiration indicated by mouth pressure and airflow signals. The activation of the occlusion trigger initiated two occlusions within a single inspiration of 150 ms each separated by a 500 ms interval. A minimum of 64 inspiratory occluded breaths were recorded in each condition. A parallel marker signal was sent to the EEG computer. An occlusion valve produced the occlusion of the inspiratory port. Upon completion of each condition, i.e. unpleasant and neutral, subjects rated the intensity of perceived respiratory sensation on a modified Borg scale from 0 (nothing at all) to 10 (maximal).

2.6. Respiratory monitoring

Airflow was continuously recorded from a pneumotachograph connected to a differential pressure transducer connected to a